A Preliminary Report on *Parathunnus sibi* in Hawaiian Waters and a Key to the Tunas and Tuna-like Fishes of Hawaii[1]

VERNON E. BROCK[2]

THE BIGEYE TUNA, *Parathunnus sibi* (Temminck & Schlegel), is an important part of the catch of large tunas from Hawaiian waters (Table 1), and yet it is so little known that it seems desirable to publish the preliminary data obtained by the Division of Fish and Game of Hawaii concerning it. These data may be conveniently considered in three categories: (1) field identification of the species principally by external characters, (2) morphometric data, which may be useful in later racial studies as the species is an important one in Japanese as well as Hawaiian landings (Shapiro, 1948: Table 8), and (3) some ecological information based largely on the characteristics of the fishery for the species in Hawaii. Some incidental information on the commercial importance of this species and on the method of taking it is also given.

Parathunnus sibi has been reported from Hawaiian waters by Kishinouye (1923: 444), Jordan and Evermann (1926: 17), and Fowler (1928: 134). Kishinouye's report was hearsay and the descriptions by Jordan and Evermann and by Fowler are hardly sufficient for certain identification. Based on a single sight identification in the San Pedro markets, Kishinouye also reported the occurrence of this species on the west coast of North America. Since then Godsil and Byers (1944: 105–119) have discussed in detail two small specimens from the west coast of Central America. *P. sibi,* originally described from Japanese waters, would seem to span the tropical Pacific in its range.

In the spring of 1948, during a morphometric study of Hawaiian yellowfin tuna, *Neothunnus*

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[2] Director, Division of Fish and Game, Board of Agriculture and Forestry, Honolulu, Hawaii.

TABLE 1

LANDINGS OF YELLOWFIN AND BIGEYED TUNA IN THE TERRITORY OF HAWAII, 1947 AND 1948

MONTH	YELLOWFIN		BIGEYED	
	1947	1948	1947	1948
	pounds	*pounds*	*pounds*	*pounds*
January	58,277	87,661	14,496	64,434
February	70,494	92,664	24,079	108,374
March	21,955	88,671	28,472	78,065
April	89,652	72,469	24,176	78,739
May	86,843	60,209	13,661	40,407
June	161,988	123,014	10,086	26,644
July	173,673	130,005	14,858	19,761
August	197,949	132,629	15,646	15,616
September	139,831	96,162	7,077	21,835
October	101,675	71,703	14,455	40,808
November	95,396	102,483	62,393	76,526
December	116,616	100,441	101,269	99,128
Totals	1,314,349	1,158,111	330,668	670,337

macropterus, the identification of the species subsequently determined to be *Parathunnus sibi* proved to be most puzzling until an examination of internal characters was made. It was possible, by inspection, to divide the catch of large tunas auctioned in the Honolulu fish markets into two kinds, both of which, insofar as external characters went, agreed substantially with the available descriptions of *Neothunnus macropterus.* It was suspected that one of the kinds was *Parathunnus* because of its large eye, large head, coarser scalation, and thick, heavy body. However, the available descriptions of *Parathunnus* differed in a number of respects from these fish. Although Kishinouye mentioned that the pectoral fin was relatively shorter in larger fish, Kishinouye as well as Godsil and Byers described *Parathunnus mebachi* Kishinouye, which is here regarded as a synonym of *Parathunnus sibi* (Temmnick & Schlegel), as having a long pectoral fin reaching beyond the anal insertion and to or beyond the anal fin base. The Hawaiian fish examined by me have a pectoral fin which is shorter than that of *Neothunnus* of comparable size and which usually does not reach as far as the insertion of the anal fin. Kishinouye described the anal finlets of *P. sibi* as grayish with a yellow margin; Fowler, who was familiar with Hawaiian material, reported that the finlets were without yellow markings. However, the finlets examined by me have been yellow or orange-yellow with black borders. A 100-pound specimen, the smallest available after several weeks of checking the markets, was purchased for dissection. A study of the internal characters of taxonomic importance—such as the arrangement of the cutaneous circulatory system and the marginal striations on the liver—indicated that the fish was a *Parathunnus,* probably *P. sibi* (Temmnick & Schlegel).

One of the most obvious differences between the Hawaiian specimens of *P. sibi* and the descriptions of this species in literature is, as has been mentioned above, in the relative length of the pectoral fin. Kishinouye's Figure 47 (1923: Pl. 27) shows the tip of the pectoral fin reaching to a vertical line beyond the anal fin base. The photograph of one of the two specimens described by Godsil and Byers (1944: Fig. 59) shows approximately the same relationship. The pectoral fin in the Hawaiian *Parathunnus,* at least in the size range examined by the Division of Fish and Game staff, hardly reaches a vertical line through the insertion of the second dorsal fin, and does not reach the anal insertion at all.

There is an apparent difference in the relative length of the pectoral fins of Hawaiian specimens and of species described in the literature. This is probably attributable to the great differences in size range of fish examined in Hawaii and elsewhere.

However, if the assumption is made that the relationship between the pectoral fin length and total body length is linear when logarithms of the body length are used, then the difference between the Hawaiian material and the available descriptions may be reconciled. Since it seemed to fit his data best, Schaefer (1948) assumed a relationship of this kind between pectoral fin length and body length for *Neothunnus.* Though no proof of the assumption will be offered here for *Parathunnus,* it seems logical to assume that a similar relationship may exist. Where two variables are related linearly when the logarithms of one of them are used, then with an increase in the variables, the variable transformed into logarithmic form will increase much more rapidly on an arithmetical basis than the other. Hence as the fish becomes longer, the pectoral fin becomes relatively shorter, and conversely the smaller fish would have, therefore, relatively much longer pectoral fins. The size range of the Hawaiian *Parathunnus* here reported was 1,191 to 1,900 mm. The specimen figured by Kishinouye (1923), and referred to as immature, was approximately 750 mm. long as estimated by the scale indicated on the plate. The two specimens examined by Godsil and Byers (1944) were 569 mm. and 910 mm. in length, respectively. A line fitted to pectoral fin length and the logarithms of total

length by the method of least squares, when projected for the sizes smaller than those included in the Hawaiian data, indicates that the smaller fish would have, relatively, a much longer pectoral fin. It would seem futile, therefore, to diagnose tunas by such characters as fin lengths without first examining the fins throughout the size range of a species.

Table 2 contains measurements and counts of 20 specimens made in the Honolulu fish markets during the early summer of 1948. The method of measuring and counting described by Godsil and Byers (1944: 125–128) was followed. All measurements were made with large calipers with one fixed and one sliding arm, held parallel. As may be noted in Table 2 characters listed were not determined for all fish. This was because the measurements were made during an auction of the fish, the only practical time and place in which to measure them, and fish would occasionally be purchased and butchered before measurements could be completed. Similarly, it was not possible to determine the sex of all fish since sexes were determined by observation while a dealer butchered his recently acquired merchandise.

The computations for the regression lines for the various characters given in Table 2 have not been given here, since such comparisons of regression lines can be made with comparable data obtained for other localities and by statistical methods that seem appropriate. It does not seem worthwhile to suggest the design of a statistical scheme of analysis here by computing part of it, especially since most workers would prefer to take the field data as given in Table 2 as their starting point.

Table 1 and Figure 1 show that the largest landings of *Parathunnus* are made during the winter months. Many of the fishermen alter their gear during this period to increase the catch of this species. The Hawaiian catch of *Parathunnus* is taken on flagline or longline gear. This is an unanchored set line with hooks at approximately 30-fathom intervals and floated by buoys in deep water. The hooks are attached to leaders up to 20 fathoms long in fishing for *Neothunnus* during the summer months. In fishing for *Parathunnus,* and *Neothunnus* too, during the winter months these leaders are often lengthened several fathoms. For a detailed description of longline gear see Shapiro (1948: 40–44). *Parathunnus,* aside from the occasional capture of small individuals, is rarely taken by surface fishing techniques such as trolling or fishing with live bait.

This information would imply that *Parathunnus* is not a surface fish but that, at least during daylight, it feeds in the layers below 20 fathoms. The large eye characteristic of the species would lend weight to such an assumption. Kishinouye's discussion (1923: 444–445) of the habits of the species likewise indicates that it is not a surface fish but may approach nearer the surface at night.

Parathunnus, as taken in the Hawaiian flagline fishery, is a large tuna. Examples under 80 pounds are rare; the average weight of the specimens landed during January to September, 1948, for example, was 157.8 pounds. The maximum weight of this species landed in Hawaiian waters approaches or exceeds 300 pounds. Kishinouye, however, gives a maximum weight of 86 kilograms (190 pounds) for Japanese examples, but as he states that a fish of this weight would be about 2 meters long, it is probable that his estimate of the maximum weight is in error. A 2-meter long specimen with the body proportions of the Hawaiian fish would weigh about 334 pounds.

The fact that *Parathunnus* is rarely taken by surface fishing methods has some interesting connotations. The present fishing grounds for the species in the Pacific are those grounds on which flagline fishing gear is employed. Although in Hawaii *Parathunnus* is from one-half to two-thirds as important as *Neothunnus* in the landings of large tunas, in Japanese landings (Shapiro, 1948, table 8) in some years, it was far more important than *Neothunnus.* Aside from the two specimens discussed by Godsil and Byers (1944: 105–119) and one

TABLE 2

MORPHOMETERIC DATA (LISTED IN ASCENDING ORDER BY LENGTH) FOR 20 HAWAIIAN PARATHUNNUS*

Total length	1,191	1,236	1,279	1,290	1,342	1,372	1,373	1,422	1,470	1,475	1,495	1,542	1,570	1,592	1,593	1,670	1,697	1,760	1,783	1,900
Date†	4/14	4/14	6/2	4/16	6/2	4/16	4/16	6/2	4/12	4/13	6/2	5/25	5/6	5/25	3/24	4/12	5/13	5/17	4/14	6/4
Weight	83	90	98	101	115	137	128	125	163	151	145	164	180	181	189	214	201	248	261	275
Head length	354	369	372	382	404	404	409	410	447	429	447	450	457	461	467	480	469	497	516	533
From snout tip to 2nd dorsal insert	649	679	686	712	734	743	763	748	823	811	825	819	847	862	858	884	878	916	940	989
From snout tip to anal insert	730	759	774	779	834	837	844	862	929	901	905	919	940	998	970	.....	1,024	1,026	1,083	1,114
From snout tip to pectoral insert	359	365	380	385	397	400	406	419	450	420	446	446	448	457	471	472	468	487	514	526
Greatest body depth	331	339	356	353	352	391	509	369	412	425	382	419	417	411	425	.....	435	487	480	480
Place of greatest body depth	7-D	7-D	8-D	7-D	6-D	9-D	9-D	7-D	7-D	6-D	7-D	7-D	7-D	8-D	.....	.....	4-D	6-D	8-D	7-D
Length base 1st dorsal	315	331	321	329	346	359	349	336	397	377	382	383	395	412	377	.....	398	428	450	500
Anal fin length	161	200	195	187	188	196	176	223	232	214	209	225	242	243	260	252	252	274	266	268
2nd dorsal fin length	149	192	200	195	205	193	183	215	257	231	214	233	253	238	.....	245	254	278	264	263
Spread of caudal	431	465	467	432	480	469	460	495	.....	525	522	598	579	566	635	.....	642	688	719	707
Pectoral fin length	330	401	374	357	368	357	341	383	366	366	371	377	386	373	382	380	370	396	413	351
Gill raker count	9/19	7/18	9/19	9/18	9/19	8/19	8/19	9/18	.....	6/20	9/20	9/19	8/18	7/20	9/18	.....	9/18	7/17	8/18	8/18
Sex	♀	♂	.....	♀	.....	.....	.....	.....	♂	.....	.....	♀	.....	.....	♀	♀	♂	.....	♂	.....

* Weights are in pounds and lengths are in millimeters. Place of greatest body depth (7-D, 8-D, etc.) refers to the seventh or eighth dorsal spine. In the gill raker count (9/19, 7/18, etc.) the first number refers to the number of gill rakers on the upper limb of the gill arch, the second number to the number of gill rakers on the lower limb.

† Measurements made on dates indicated in March, April, May, and June, 1948.

mentioned by Kishinouye (1923: 444), *Parathunnus* is not known from the eastern tropical Pacific, yet it may well be abundant in the tuna grounds now exploited by the California tuna fishermen. Its abundance in the eastern Pacific will not be determined until fishing gear capable of taking it is tried in those waters.

The *Parathunnus* fishery serves to point up the fact that the fishing techniques now available for taking oceanic species may be inadequate to exploit these species in proportion to their actual abundance in the sea. There is a possibility that in some areas now fished, marine food resources of considerable magnitude, not only untapped but unknown, may exist.

KEY TO THE TUNAS AND TUNA-LIKE FISHES OF HAWAII

The following key is to the tunas and tuna-like fishes reported from Hawaiian waters. Those species marked with an asterisk are commonly taken about the Hawaiian Islands; those not so marked either do not occur in this area, or else are rare, and have not been seen by the author among fish landed at any Hawaiian port.

Two species, *Sematbunnus itosibi* (Jordan and Evermann) and *Grammatorcynus thompsoni* (Fowler), described from the Hawaiian Islands are not included in the key. *Sematbunnus itosibi* = *Neothunnus macropterus,* as understood here; *Grammatorcynus thompsoni* is probably a scomberomorid or gempylid synonymous with *Lepidocybium flavo-brunneum* (Smith).

1. First dorsal fin with 10 to 18 spines; body not over five times as long as greatest depth 2
   First dorsal fin with about 25 spines; body long and slender, at least six and a half times as long as greatest depth. Ono ....**Acanthocybium solandri* (Cuvier & Valenciennes)

2 (1). Body completely scaled, scales may be enlarged in corselet and on lateral line 5
   Body naked, without scales, except for the scaly corselet and lateral line 3

3 (2). The last spine in the first (spinous) and the first ray in the second (soft rayed) dorsal fins close to-

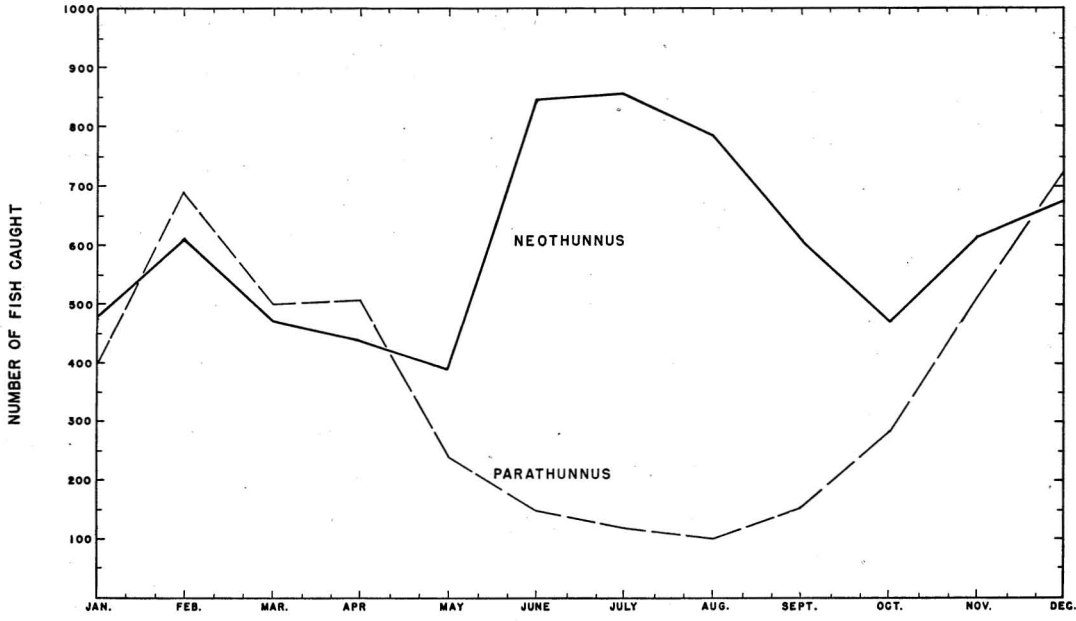

FIG. 1. Number of tuna caught by flagline in Hawaiian waters during 1948.

gether, separated by a distance equal to about one-fifth of head length 4
The first and second dorsal fins far apart, separated by a distance equal to about one-half the head length or more. Frigate mackerel .....**Auxis thazard* (Lacepede)

4 (3). Four dark longitudinal stripes present on lower surface below lateral line of side and on belly. Aku .. ....**Katsuwonus pelamis* (Linné)
No dark longitudinal stripes below lateral line, about 12 dark wavy streaks on back. Kawakawa.... ...**Euthynnus yaito* (Kishinouye)

5 (2). Dorsal finlets with some yellow, usually largely yellow 7
Dorsal finlets without any yellow markings 6

6 (5). Spines in first dorsal fin 14 or fewer in number. Bluefin tuna ....*Thunnus thynnus* (Linné)
Spines in first dorsal fin 18 in number. Bonito .....*Sarda chilensis* (Cuvier & Valenciennes)

7 (5). Gill rakers on upper and lower branch of first gill arch fewer than 32 in number, usually fewer than 30 8
Gill rakers on upper and lower branch of first gill arch 36 to 39 in number; pectoral fin does not reach to a vertical through second dorsal fin insertion; anal finlets silvery. Black tuna, Maguro ....*Thunnus orientalis* (Temmnick & Schlegel)

8 (7). Gill rakers on upper and lower branch of first gill arch 24 or more in number; air bladder present; pectoral fin reaches, in most of the species included here, to or beyond a vertical through the last spine of the first dorsal fin 9
Gill rakers on upper and lower branch of first gill arch 23 or fewer in number; no air bladder; pectoral fin does not reach to a vertical through caudal end of first dorsal fin; size small, usually less than 25 pounds ....*Kishinoella rara* (Kishinouye)

9 (8). Anal finlets with yellow or orange color; a vertical line through tip of pectoral fin usually falls anterior to end of anal fin base, at least in larger specimens of over 70 or 80 pounds 10
Anal finlets dusky without yellow or orange color; a vertical line through tip of pectoral fin usually falls posterior to end of anal fin base; size medium to small, rarely more than 70 or 80 pounds, usually much less. Albacore ....**Germo alalunga* (Gmelin)

10 (9). Dorsal and anal finlets a clear yellow, very narrowly black edged; some large individuals of this species may have elongate second dorsal and anal fins, reaching nearly to the caudal fin or beyond; number of gill rakers on upper and lower limb of first gill arch usually 30 (27 to 31); liver without marginal striations. Yellowfin tuna, Ahi ....**Neothunnus macropterus* (Temmnick & Schlegel)
Dorsal and anal finlets with a broad black border, anal finlets often with an orange rather than yellow color; second dorsal and anal fins never greatly elongated, a little longer than the longest spines of the first dorsal fin and much shorter than pectoral fin; number of gill rakers on upper and lower limb of first gill arch usually 27 (24–29); liver with marginal striations. Bigeye tuna .....**Parathunnus sibi* (Temmnick & Schlegel)

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